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A new species of the genus *Gekko* Laurenti, 1768 (Squamata: Gekkonidae) from the Nicobar Archipelago, with an overview of congeners from the Andaman and Nicobar Islands

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***Abstract.*—A comprehensive systematic review of the genus *Gekko* Laurenti, 1768 in the Andaman and Nicobar archipelago was undertaken. The known members *Gekko verreauxi* Tytler, 1865 and *Gekko* (*Ptychozoon*) *nicobarensis* (Das and Vijayakumar, 2009) are redescribed based on new material collected during this study. The systematic status of the *Gekko smithii* (s. lat.) population from the southern Nicobar Islands was reassessed and found to represent a distinct species. Based on morphological and morphometric distinction, this allopatric, insular population is described as *Gekko stoliczkai* sp. nov. Notes on ecology, natural history, morphology, and distribution are presented for all these species, with recommendations on their conservation status.**

Keywords. Asia, cryptic species, endemic species, giant gecko, Reptilia, Sundaland

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Introduction

The nocturnal, arboreal members of the true gecko genus, *Gekko* Laurenti, 1768, are currently represented by 77 species, which range from eastern India to Papua New Guinea (Uetz et al. 2020). Wood et al. (2019) recently partitioned *Gekko* into seven subgenera, including two previously recognized genera, *Ptychozoon* Kuhl and van Hasselt, 1822 and *Luperosaurus* Gray, 1845. The Andaman and Nicobar Islands, situated to the east of the Indian peninsula and south of the Ayeyarwady Delta region of Myanmar, lie on the western periphery of the geographic range of the genus *Gekko*. Currently, this genus is represented by three species within the Andaman and Nicobar archipelago, namely *Gekko verreauxi* Tytler, 1865 from the Andaman Islands, *Gekko* (*Ptychozoon*) *nicobarensis* (Das and Vijayakumar, 2009) from the Nicobar Islands, and a species from the Nicobar Islands currently identified as *Gekko smithii* Gray, 1842 (Uetz et al. 2020). Of these, *Gekko verreauxi*, the earliest species known from the Andaman and Nicobar Islands, was reported from the Andaman Islands as *Gekko gecko* (Linnaues, 1758) as early as Blyth (1863). *Gekko verreauxi* was once considered a synonym of *G. stentor*, which again, was a junior synonym of *G. smithii* (*fide* Boulenger, 1885) before being revived as a valid species by Ota et al. (1991) based on an examination of type material. This was followed by the report of *Ptychozoon homalocephalum* [now *Gekko* (*Ptychozoon*) *nicobarensis*] from the Nicobars by Steindachner (1867), which was apparently overlooked by Das and Vijyakumar (2009). The third species from this Archipelago, *Gekko smithii*, was reported by Biswas and Sanyal (1977) from Great Nicobar as *Gekko gecko* (in this study regarded as *Gekko* cf. *smithii*), based on specimens at the Bombay Natural History Society (BNHS) collected by Humayun Abdulali. Subsequently, Biswas (1984) reported additional *Gekko smithi* (*sic*) records from the South Andaman and Great Nicobar Islands. Veselý (1999) provided additional notes on the morphology and distribution of *Gekko verreauxi*. Das (1999) speculated that the Nicobar population of *G. smithii* was potentially allied to an undescribed member of this group from Sumatra and specifically distinct from the nominate species, *Gekko smithii*. Here, we examine the three species of *Gekko* of the Andaman and Nicobar Islands; provide additional data on the morphology,

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natural history, and distribution of *G. verreauxi* and *G.* (*P*). *nicobarensis*; and reassess the taxonomic status of *Gekko* cf. *smithii* populations from the Nicobar archipelago.

Materials and Methods

Specimens of *Gekko* encountered in the field were gently restrained, measured, scored for morphological characters (see below), photographed, and released at the site of capture. Four specimens of *G. verreauxi* were collected from the Andaman Islands, three specimens of *G.* (*Ptychozoon*) *nicobarensis* were collected from Car Nicobar, Camorta, and Teressa Islands, and five specimens of the *G.* cf. *smithii* were collected from Great and Little Nicobar Islands in and around human habitations between 2014 and 2017. These specimens were preserved in 70% ethanol and are deposited in the two collections of the Zoological Survey of India, Andaman and Nicobar Islands Regional Centre, Port Blair, India (ZSI, ANRC) and the Department of Ocean Studies and Marine Biology (DOSMB), Pondicherry University, Brookshabad, Port Blair, India.

The following measurements (in mm) were recorded with vernier calipers: Snout-vent length (SVL), measured from the snout tip to the anterior edge of the cloaca; tail length (TAL), measured from the posterior edge of the cloaca to the tail tip; trunk length (AG), measured between the axilla and groin; head length (HL), measured from the snout tip to the angle of the jaw; head width (HW), measured at the widest point on the head; head depth (HD), measured from the top of the head to the throat, at the level of the eyeball; horizontal eye diameter (ED), eye-nostril distance (EN), measured from the anterior margin of the eye to the posterior margin of the external nares; snout length (ES), measured from the anterior margin of the eye to the tip of the snout; distance from eye to tympanum (ETY), measured from posterior margin of the eye to the anterior edge of the tympanum; tympanum diameter (TYD), measured across the widest point of the tympanic opening; upper arm length (UAL), measured from the axilla to the elbow; lower arm length (LAL), measured from the elbow to the wrist; palm length (PAL), measured from the wrist to the tip of finger III; thigh length (FEL), measured from the point of insertion of the hind limb on the trunk to the knee; tibia length (TBL), measured from the knee to heel; foot length (FOL), measured from heel to the tip of toe IV; and lengths of fingers (F1–F5) and toes (T1–T5) measured from the fork of the digits to the tip excluding the claws. Supralabials and infralabials were counted along the upper and lower lips from rostral and mental to the gape, respectively. Enlarged scales bordering the mental posteriorly were counted as postmentals, and expressed as inner pair + outer pairs. Ventrals were counted along a transverse series across the underside at mid-body between the ventrolateral folds; internasals were counted between the nasal scales; subdigital lamellae were counted on the ventral surface of digits of the fingers and toes, and dorsal tubercle rows were counted in a transverse series at the mid-body. GPS coordinates of the localities where the individuals were encountered were recorded with a Garmin GPS MAP 78s and mapped with ARC MAP v. 10. Comparative material of the Sundaic *G. smithii* are provided in the Appendix.

The following analyses were carried out to test the hypothesis that the Nicobar population of *Gekko smithii* is morphologically distinct from those of the Sundaic regions. A Student's *t*-test was conducted on meristic and mensural data (see below) with statistically similar variances (i.e., p values >0.05 in a Levene's test) and normal distributions (i.e., p values > 0.05 in a Shapiro-Wilk's W test) to search for the presence of statistically significant mean differences ($p < 0.05$) among species across the data set. Boxplots were generated for all characters in order to visualize the range, mean, median, and degree of differences between species pairs bearing statistically different mean values. All statistical analyses were performed in R (v3.4.3). The morphospatial clustering of the sampled individuals was visualized using Principal Component Analysis (PCA) from the ADEGENET package in R (Jombart et al. 2010) implemented by the *prcomp*() command. PCA is a dimension-reducing algorithm that decreases the complexity of a data set by finding a subset of input variables that contain the most relevant information (i.e., the greatest variance in the data) while de-emphasizing those characters that do not, thus increasing the overall accuracy of the results by eliminating noise and the potential for overfitting (Agarwal et al. 2007). PCA is an unsupervised analysis that recovers morphospatial relationships among the sampled individuals (i.e., data points). It is important to note that clusters of conspecific individuals were not pre-defined in the analysis but simply color-coded in the scatter plot in order to observe their positions and morphospatial relationships. Meristic data were log-transformed prior to analysis in order to normalize their distributions, so as to ensure that characters with very large and very low values could not over-leverage the results owing to intervariable nonlinearity. To help remove the potential effects of allometry in the mensural characters, only adults were collected (as determined by SVL). Additionally, variation in adult size was normalized using the following equation: $X_{adj}=\log(X)-\beta[\log(SVL)-\log(SVL_{mean})]$, where X_{adj} = adjusted value; X = measured value; β = unstandardized regression coefficient for each population; and SVL_{mean} = overall average SVL of all populations (Thorpe 1975, 1983; Turan 1999; Lleonart et al. 2000; Tables 1 and 2). The metrics of each species were normalized separately to avoid conflating intra- with interspecific variation (Reists 1986). Meristic and mensural data were not concatenated but analyzed separately owing to differences in sample sizes. All data were scaled to their standard deviations

Table 1. Summary statistics and Principal Component Analysis scores for the meristic characters.

	PC1	PC2	PC3	PC4	PC5	PC6
Standard deviation	1.384	1.217	0.994	0.860	0.813	0.463
Proportion of variance	0.319	0.247	0.165	0.123	0.110	0.036
Cumulative proportion	0.319	0.566	0.731	0.854	0.964	1.000
Eigenvalue	1.916	1.480	0.988	0.740	0.661	0.214
Internasals	-0.223	0.524	-0.070	-0.810	0.111	-0.050
Infralabials	-0.578	-0.388	-0.077	-0.013	0.225	-0.678
Supralabials	-0.633	-0.265	-0.138	-0.026	0.019	0.714
Postmentals	-0.399	0.417	0.056	0.281	-0.748	-0.158
4th toe lamellae	-0.153	0.026	0.974	-0.008	0.155	0.057
Ventrals	-0.182	0.575	-0.136	0.513	0.594	0.029

to insure they were analyzed on the basis of correlation and not covariance. A Discriminant Analysis of Principal Components (DAPC) was performed on both data sets. The DAPC places individuals from each predefined population into separate clusters (i.e., plots of points) bearing the smallest within-group variance that produce linear combinations of centroids having the greatest between-group variance (i.e., linear distance; Jombart et al. 2010). DAPC relies on scaled data calculated from its own PCA as a prior step to ensure that the variables analyzed are not correlated and number fewer than the sample size. Dimension reduction of the DAPC prior to plotting was accomplished by retaining the first set of PCs that accounted for approximately 90% of the variation in the data set (Jombart and Collins 2015) as determined from a scree plot generated as part of the analysis. Retaining too many PCs forces false structure to appear in the data, while retaining too few runs the risk of missing true structure (Cangelosi and Goriely 2007).

Additional museum abbreviations are: NHMUK – The Natural History Museum, London (formerly, BMNH – British Museum of Natural History), FMNH – Field Museum of Natural History, Chicago, Illinois, USA; USNM – National Museum of Natural History, Washington, DC, USA; THMNH – Thailand Natural History Museum; LSUHC – La Sierra University, Herpetology Collection; ZMA – Universiteit van Amsterdam, Zoologisch Museum, Amsterdam, Netherlands; ZRC: Zoological Reference Collection, Department of Zoology, University of Singapore.

Results

The results of the analyses support our initial hypothesis that the Nicobar and Sundaic populations of *Gekko smithii* are morphologically distinct. The PCA of the meristic data show that the Nicobar population overlaps with the Sundaic *Gekko smithii* along principal component (PC) 1 but is generally well-separated from Sundaic *G. smithii* along PC 2 (Fig. 1). PC1 accounts for 31.9% of the variation in the data set and loads most heavily for infralabials and supralabials (Table 1), while PC2 accounts for 24.7% of the variation and loads most heavily for postmentals and internasals. Four PC eigenvalues and the first discriminate function were retained for the DAPC, which accounted for 92.9% of the

Table 2. Summary statistics and Principal Component Analysis scores for the mensural characters. Abbreviations are defined in the text.

	PC1	PC2	PC3	PC4	PC5	PC6	PC7	PC8	PC9	PC10
Standard deviation	2.713	0.930	0.745	0.589	0.526	0.442	0.364	0.348	0.318	0.221
Proportion of variance	0.736	0.087	0.056	0.035	0.028	0.020	0.013	0.012	0.010	0.005
Cumulative proportion	0.736	0.822	0.878	0.912	0.940	0.960	0.973	0.985	0.995	1.000
Eigenvalue	7.358	0.865	0.555	0.347	0.276	0.195	0.132	0.121	0.101	0.049
HD	0.322	-0.250	-0.109	0.009	0.738	-0.011	-0.071	0.165	-0.426	-0.251
HL	0.340	0.157	-0.035	-0.162	-0.329	0.034	-0.776	-0.117	-0.144	-0.292
HW	0.324	-0.220	-0.385	-0.359	0.092	0.136	0.107	-0.046	0.701	-0.195
TYD	0.316	-0.297	-0.033	0.459	-0.173	-0.741	-0.002	-0.010	0.144	0.002
EN	0.320	-0.270	-0.117	0.381	-0.404	0.529	0.336	-0.091	-0.260	-0.182
ES	0.356	-0.103	-0.055	0.023	0.023	0.208	-0.226	0.259	0.025	0.835
ED	0.208	0.777	-0.447	0.336	0.146	-0.021	0.127	-0.022	0.041	0.010
UAL	0.285	0.179	0.743	0.281	0.229	0.210	-0.034	-0.052	0.374	-0.122
LAL	0.340	0.088	0.147	-0.372	0.033	-0.171	0.280	-0.707	-0.236	0.230
AG	0.327	0.222	0.215	-0.398	-0.265	-0.181	0.348	0.615	-0.144	-0.127

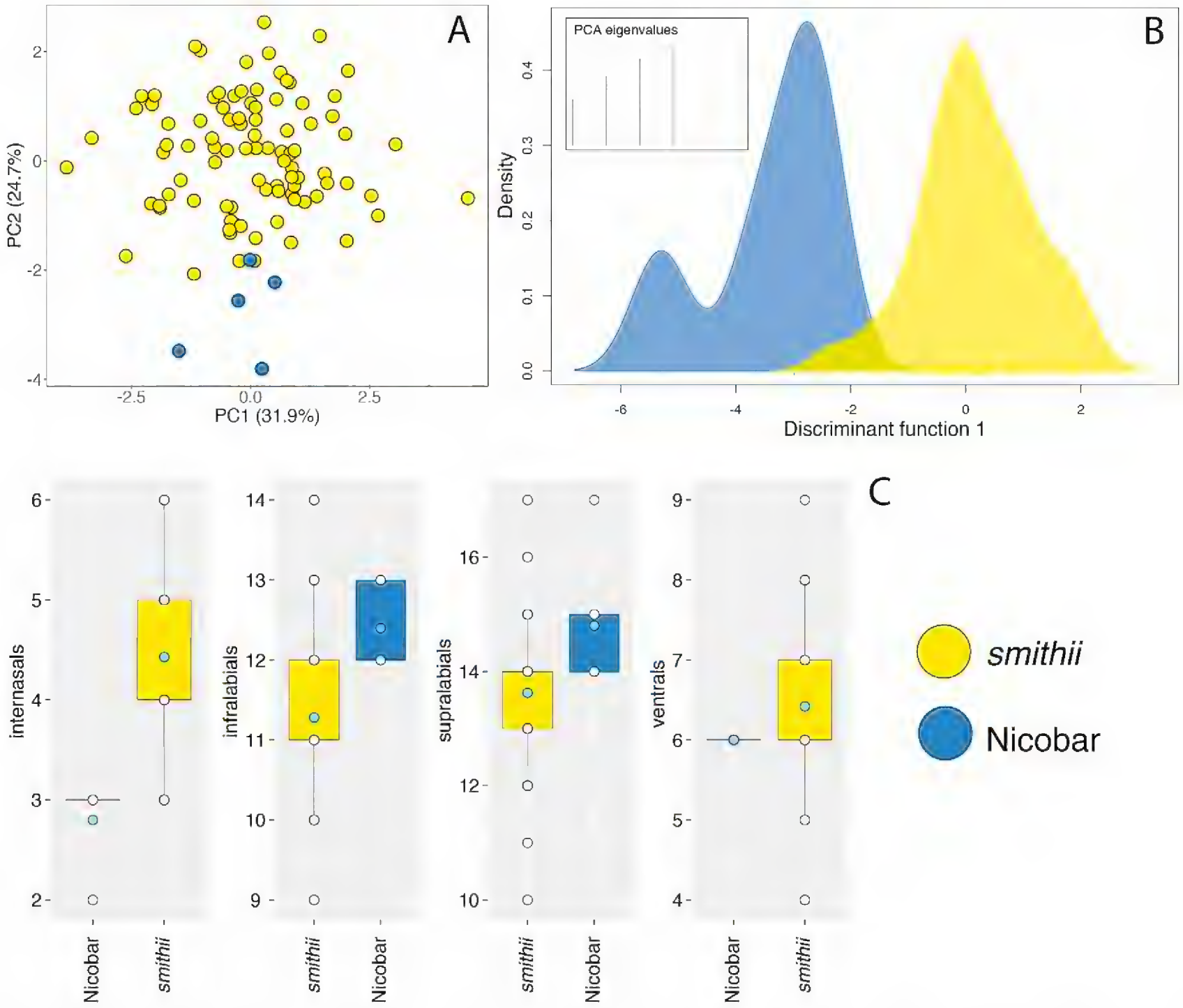

Fig. 1. Analyses of meristic characters. **(A)** First two principal components of the PCA. **(B)** Density curves of the first discriminant function of the DAPC. **(C)** Boxplots in which light-blue circles are the means and the black horizontal bars are the medians.

variation and demonstrated very little overlap between the Nicobar population and *G. smithii*. These results are mirrored by the mensural data, where the PCA of the mensural data show that the Nicobar population and *Gekko smithii* plot completely separately from each other (Fig. 2). PC1 accounts for 73.6% of the variation in the data set and loads fairly evenly for all characters, except for low loadings for the eye diameter and forelimb length (Table 2). PC2 accounts for 8.8% of the variation and loads most heavily for eye diameter. Six PC eigenvalues and the first discriminate function were retained for the DAPC, which accounted for 97.1% of the variation and demonstrated no overlap between the Nicobar population and *G. smithii*. Student *t*-tests also showed several statistically significant mean differences between the Nicobar population and *Gekko smithii* in both meristic and mensural characters (Table 3; Figs. 1–2).

Based on the data presented above, we believe there is sufficient evidence to formulate a robust, testable hypothesis indicating the Nicobar population is a distinct species, and as such, is described below. In addition, we redescribe the species *G. verreauxi* and *G. nicobarensis* based on our new data.

Taxonomy

***Gekko* (*Gekko*) *verreauxi* Tytler, 1865 (Figs. 3–4)**
Gekko verreauxi Tytler, 1865
Gekko stentor – Boulenger (1885) part
Gekko smithii – Smith (1935) part

Table 3. Results of Student *t*-tests.

	***p*-value**	***t*-value**
Mensural characters		
Head length	1.71E-06	-5.1
Head width	0.02105	-2.3457
Snout length	0.02042	-2.3577
Eye diameter	1.65E-10	-7.1575
Forelimb length	0.01159	-2.5737
Tibia length	2.13E-05	-4.4714
Axilla-groin length	8.11E-07	-5.2777
Meristic characters		
Internasals	8.40E-07	-5.2692
Infralabials	2.23E-02	2.3234
Supralabials	0.028	2.2311
Ventrals	0.003089	-3.0357

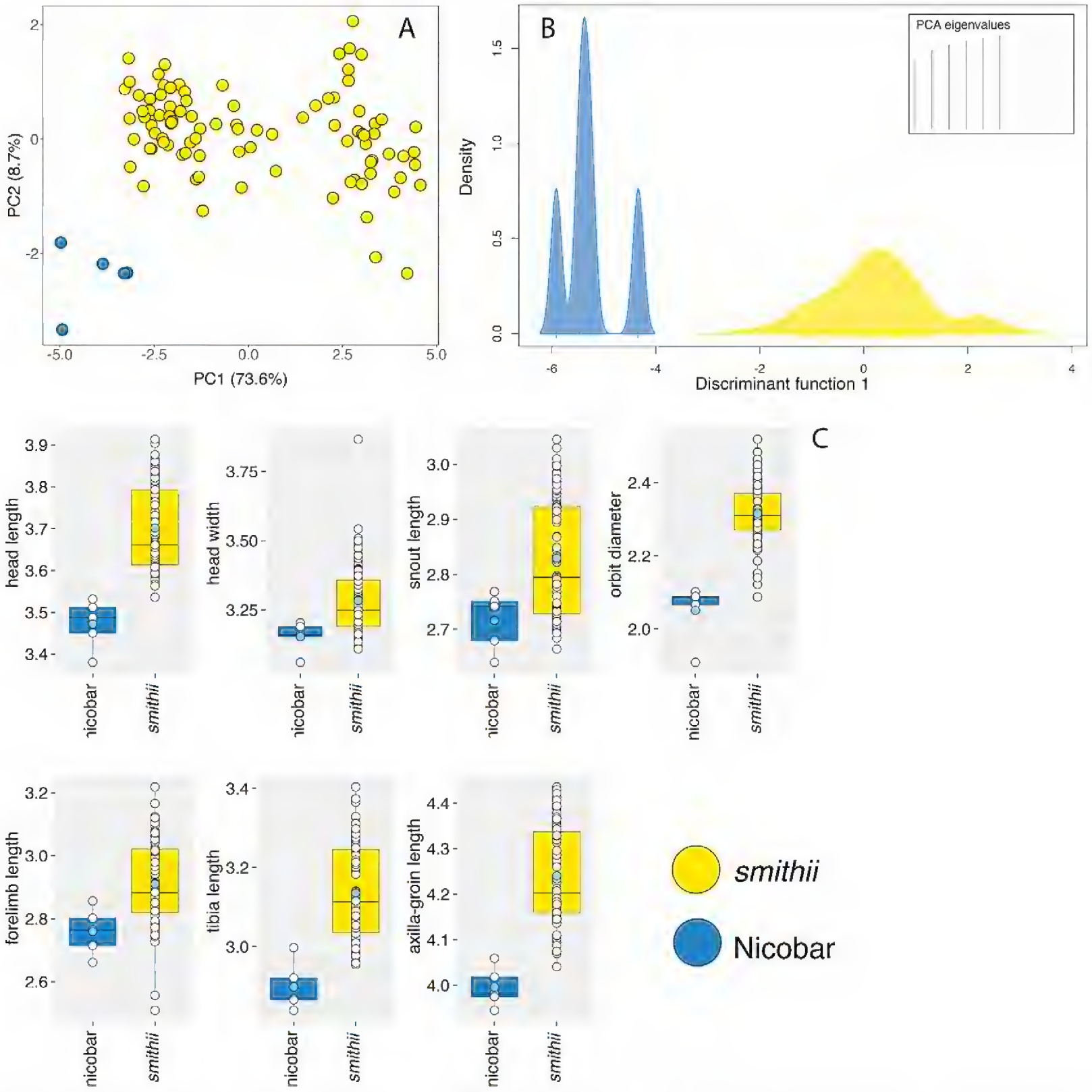

Fig. 2. Analyses of mensural characters. **(A)** First two principal components of the PCA. **(B)** Density curves of the first discriminant function of the DAPC. **(C)** Boxplots in which light-blue circles are the means and the black horizontal bars are the medians.

Lectotype. NHMUK 68.4.3.64, an adult female collected from the 'Andaman Islands' by W. Theobald *fide* Ota et al. (1991) (photographs studied).

Paralectotype. NHMUK 1868.4.3.65, an adult female from the same location (photographs studied).

Material studied. ZSI/ANRC/T/4324 from Majarpahar (11.7029°N, 92.6433°E, 16 m asl), South Andaman; ZSI/ANRC/T/3726 from Durgapur (13.2761°N, 93.0311°E, 5 m asl), North Andaman; ZSI/ANRC/T/4566 from Rabindranagar (10.7080°N, 92.5334°E, 57 m asl), Little Andaman; ZSI/ANRC/T/5779 from Krishna Nagar (12.0086°N, 92.9635°E, 58 m asl), Swarajdweep (formerly Havelock Island).

Diagnosis. A large-bodied species of *Gekko* (SVL 140.06–146.48 mm) characterized by: 12–14 supralabials; 9–13 infralabials; two elongate inner pairs of postmentals in broad contact with each other; two smaller, separated outer pairs of postmentals; 11–13 precloacal pores in males; absence of femoral pores; two internasals in contact with each other; distinct ventrolateral dermal folds; 26–29 transverse rows of imbricate ventrals; 12 or 13 transverse rows of enlarged, rounded, dorsal tubercles; two to three enlarged post-cloacal spurs on each side of the vent; 18–20 undivided subdigital lamellae on toe IV; presence of five legible, dark, transverse bands in juveniles and subadults transforming into a nearly uniform dark-brown dorsal coloration in adults with a pale-white to light-brown venter.

Description and variation. A large species of *Gekko*, measuring 109.55–146.49 mm SVL. Head large (mean HL:SVL 0.26), longer than broad (mean HL:HW 1.19) with a blunt, rounded snout tip. Eyes moderately large (mean ED:HL 0.25) with a vertically elliptical pupil approximately one-half the length of the snout (mean ED:ES 0.53); nostrils situated closer to the snout tip

Fig. 3. *Gekko verreauxi* in life from South Andaman (top, middle, and bottom right: adult; bottom left: juvenile).

than to the eyes (mean EN:ES 0.79). Trunk one-half as long as the body (mean AG:SVL 0.46). Overall habitus depressed. Supralabials 12–14 on each side; infralabials 9–13 on each side; two moderately enlarged postmentals in broad medial contact, followed by three smaller pairs of scales. Dorsum bearing 11–13 transverse rows of enlarged tubercles. Ventrals imbricate, in 27–29 transverse rows at midbody. A pair of enlarged, rounded cloacal spurs at the base of the vent. Anterior subcaudals not enlarged, posterior ones slightly enlarged. Upper arm shorter than lower arm (mean UAL:LAL 0.79); palm enlarged with five fingers; the first one with an indistinct claw; relative lengths of fingers IV>III>V>II>I. Thighs short (mean FEL:SVL 0.16), robust bearing a few tuberculated scales on the dorsal surface. Tibia as long as the thighs (mean TBL:SVL 0.16); toes with entire, undivided subdigital lamellae, 18–20 on toe IV; relative lengths of toes IV>III>V>II>I. Fingers and toes free, lacking membranous skin flaps. Males have a series of 11–13 precloacal pores and lack femoral pores.

Coloration in life. Overall dorsal coloration uniform dark- to light-brown with five to six darker transverse bands on the body and five or six on the tail. Venter

Fig. 4. Dorsal, ventral, and lateral views of the head and ventral view of the foot of *Gekko verreauxi* (ZSI ANRC T 4566).

uniform brown and lacking any specific pattern. Eyes with vertically elliptical pupils and a greenish yellow iris.

Distribution. Occurs throughout the Andaman Islands, and was recorded from the following islands during the present study: South, Middle, North and Little Andaman, Rutland Island, Ritchie's archipelago (Havelock, Neil, John Lawrance, and Henry Lawrance), Kyd, Labyrynth archipelago (Tarmugli, Alexandra, Hobday, and Redskin), Interview, North Reef, Paget, Long, Guitar, and North Passage Islands (Fig. 10).

Natural history. Nocturnal in habit. Found on tall trees at a height of approximately 5 m and above the ground in evergreen forests. It has also been recorded from secondary forests, human habitations, and littoral forests. Calls comprise of a series of repeatedly uttered, rattling syllables of *tuk-tuk-tuk-tuk.*

Remarks. Boulenger (1885) synonymized *Gekko verreauxi* under *Gekko stentor* (Cantor, 1847), a junior synonym of *Gekko smithii* Gray, 1842. Ota et al. (1991), while revalidating *G. verreauxi* from the synonymy of *G. smithii*, provided a detailed redescription of the species with measurements and scale-counts from both the lectotype and the paralectotype. Both of these specimens are females and hence, we have supplemented the available information with new specimens, including males, in order to improve our understanding of the species. The lectotype has 14 supralabials (12–14 in our material), 10 infralabials (9–13), 11 rows of dorsal tubercles at midbody (11–13), and 21 subdigital lamellae (18–20) under toe IV.

***Gekko* (*Ptychozoon*) *nicobarensis* (Das and Vijayakumar, 2009) (Figs. 5–6)**

Ptychozoon homalocephalum – Steindachner (1867)

Ptychozoon kuhli – Stoliczka (1870); Smith (1935); Biswas and Sanyal (1977); Das (1999) part

Holotype. ZSI 2603, an adult male collected by A.R. Anderson from 'Nicobars' in the late 1800s.

Material studied. DOSMB05102 from Chuckchuka (9.2161°N, 92.8109°E, 14 m asl), Car Nicobar, ZSI/ANRC/T/5234 from Kalasi (8.2803°N, 93.1173°E), Teressa, and ZSI/ANRC/T/4235 from Chota Enaka (8.0657°N, 93.5428°E, 39 m asl), Camorta, Nicobar Islands.

Diagnosis. A medium to large-bodied (SVL 78.2–95.8 mm) species of *Gekko*, characterized by: presence of extensive, membranous skin flaps along the sides of the head, trunk, and tail; tail tip with an oval shaped

Fig. 5. *Gekko* (*Ptychozoon*) *nicobarensis* in life from Car Nicobar (above: banded; middle: striped morphs).

skin flap; presence of 10–13 supralabials; 10 or 11 infralabials; two relatively small, elongate inner pairs of postmentals in broad medial contact with each other; three smaller, separated outer pairs of postmentals; 20–21 precloacal pores in males, no femoral pores; two internasals in contact with or separated by one or two small azygous scales; no ventrolateral body folds; 29–32 transverse, juxtaposed rows of ventrals; four well-spaced, transverse rows of enlarged, rounded dorsal tubercles; one enlarged post-cloacal spur on each side of the vent; 13–21 undivided subdigital lamellae on toe IV; dorsal color pattern consisting of four or five legible, dark, W-shaped, transverse bands or a light-colored vertebral stripe bounded on either side by two darker stripes, and a creamy white to light-brown venter.

Description and variation. A medium to large-bodied species of *Gekko* belonging to the subgenus *Ptychozoon* measuring 78.42–95.86 mm SVL, head large (mean HL:SVL 0.28), much longer than broad (mean HL:HW 1.34) with a blunt, rounded snout tip. Eyes protruding, fairly large (mean ED:HL 0.25) with a vertically elliptical pupil; eye nearly half as long as the snout (mean ED:ES 0.53); nostrils situated closer to the snout tip than to the eyes (mean EN:ES 0.77). Trunk much shorter than one-half the length of the body (mean AG:SVL 0.47).

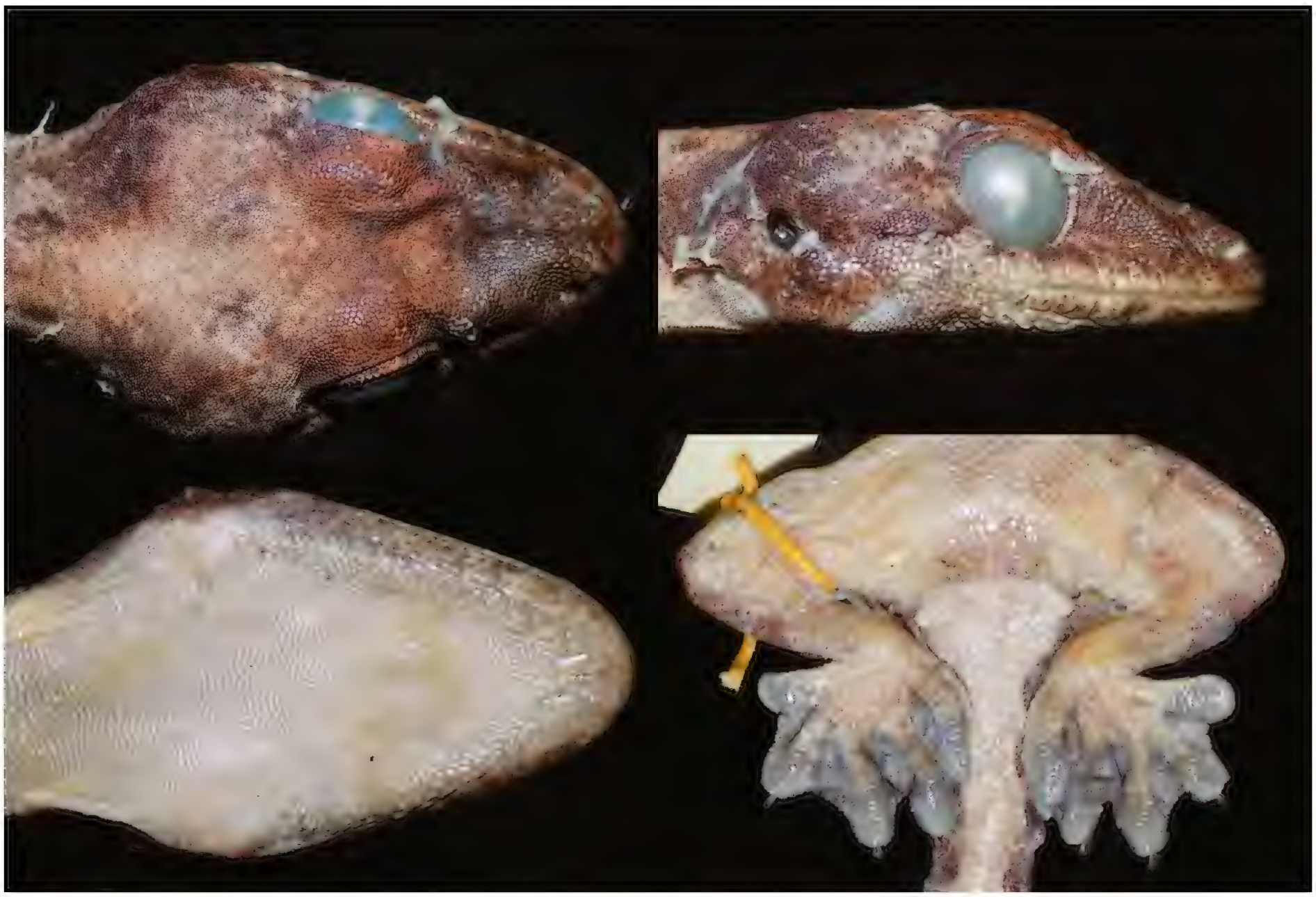

Fig. 6. Dorsal, lateral, and ventral views of the head and ventral view of the feet of *Gekko nicobarensis* (DOSMB05102).

Overall habitus depressed. Supralabials 10–13 and infralabials 10–11 on each side; two moderately enlarged postmentals in broad medial contact, followed by three pairs of scales that are nearly as large as the postmentals. Dorsum bearing four transverse rows of weakly enlarged, rather indistinct tubercles. Ventrals imbricate, in 29–32 transverse rows. Sides of the body bearing a membranous flap of skin, with enlarged, rhomboidal, imbricate scales. A pair of enlarged, rounded cloacal spurs present at the base of the vent. Subcaudals not elongated horizontally, the middle row slightly enlarged. Tail with serrated dermal membranes extending along the sides, forming an oval-shaped disc at the terminus. Tail tip regenerated. Upper arm shorter than lower arm (mean UAL:LAL 0.91); palm enlarged with five fingers; the first one with an indistinct claw; relative lengths of fingers IV>III>V>II>I. Sides of upper and lower arms with extensive skin flaps. Thighs short (mean FEL:SVL 0.18) robust; with a few tuberculated scales on the dorsal surface. Tibia shorter than thighs (mean TBL:SVL 0.16); toes with entire, undivided subdigital lamellae, 14–20 under toe IV; relative lengths of toes IV>III>V>II>I. Tibia bearing lateral flaps of skin. Fingers and toes extensively webbed with membranous skin flaps extending from the base to the tip. Males have a series of 20–21 precloacal pores and lack femoral pores.

Coloration in life. Dorsal coloration variable. Two distinct morphs recorded. One morph with a series of five or six darker brown 'W' shaped transverse bands on the body and five or six similar transverse bands on the tail. The other morph with a bright tan vertebral stripe bordered by darker flanks (Fig. 5). Venter uniform brown and lacking any specific pattern. Eyes with vertically elliptical pupils, a greenish yellow iris and brown reticulations.

Distribution. Occurs on islands of the Northern and central group of the Nicobar Archipelago. Recorded from Car Nicobar, Camorta, Katchall, and Teressa Islands during this study. It has been reported from Chowra, Bompoka, Trinkat, and Nancowry Islands (Das and Vijayakumar 2009) (Fig. 10).

Natural history. Nocturnal in habit. The individuals recorded during this study were observed mostly at a height of approximately 2–2.5 m above the ground on the trunks of relatively short shrubs that were nearly 3–3.5 m tall, with a girth not exceeding 25 cm. Found in primary evergreen forests, also recorded from secondary forests, human habitations, and plantations. Calls of this species could not be heard during the sampling sessions in the field. Pairs of eggs stuck to each other and the tree bark substrate were seen in July.

Remarks. The holotype has 11 supralabials (10–13 in our material), 9 infralabials (10–11), four rows of dorsal tubercles at midbody (4), and 21 subdigital lamellae (14–

Fig. 7. *Gekko stoliczkai* **sp. nov.** in life from Great Nicobar.

19) under toe IV.

***Gekko stoliczkai* sp. nov. (Figs. 7–9)**

Gekko gecko (non Linnaeus, 1758) – Biswas and Sanyal (1977) part

Gekko smithii (non Gray, 1841) – Biswas (1984); Das (1999); Vijayakumar (2005) part

urn:lsid:zoobank.org:act:1795181F-C7AD-4195-A233-2B2F1B13826B

Holotype. ZSI/ANRC/T/6092, an adult male collected from Makachua (7.4035°N, 93.7134°E, 37 m asl), Little

Fig. 8. Holotype (ZSI/ANRC/T/6092) of *Gekko stoliczkai* **sp. nov.** in dorsal (above) and ventral (below) views.

Nicobar Island on 14 August 2018 by G. Gokulakrishnan.

Paratypes. DOSMB05020, an adult female from Shastri Nagar (6.8065°N, 93.8882°E, 41 m asl), ZSI/ANRC/T/6093 an adult female, ZSI/ANRC/T/4796 and ZSI/ANRC/T/7221, two adult males from East-West road (7.0022°N, 93.8811°E, 82 m asl), Great Nicobar.

Etymology. The specific epithet is a patronym honoring Dr. Ferdinand Stoliczka (1838–1874) for his early contributions to the herpetology of Andaman and Nicobar Islands. Some of his works, such as Stoliczka (1870; 1873), provided significant information on the herpetofauna of the Andaman and Nicobar Islands, which included the description of several new taxa such as *Rana gracilis* var. *andamanensis* (now *Minervarya andamanensis*), *Rana gracilis* var. *nicobariensis* (now *Minervarya nicobariensis*), *Hylorana nicobariensis* (now *Bijurana nicobariensis*), *Typhlops andamanensis* (now *Gerrhopilus andamanensis*), *Ablabes nicobariensis* (now *Gongylosoma nicobariensis*), and *Mocoa macrotymapnum* (now *Lipinia macrotympanum*).

Table 4. Meristic and morphometric characters of specimens examined for **(A)** *Gekko verreauxi*, **(B)** *Gekko nicobarensis,* and **(C)** *Gekko stoliczkai* **sp. nov.** The specimen number of the new species holotype is in bold.

Table 4A. Data for *Gekko verreauxi.*

Species	*Gekko verreauxi*	*Gekko verreauxi*	*Gekko verreauxi*	*Gekko verreauxi*	Mean
Catalogue Number:	ZSI/ ANRC/T/3726	ZSI/ ANRC/T/5779	ZSI/ ANRC/T/4324	ZSI/ ANRC/T/4566	
Island	North Andaman	Havelock	South Andaman	Little Andaman	
SVL (mm)	140.06	109.55	140.62	146.49	134.18
Trunk length	67.24	41.99	69.84	66.58	61.41
Tail	93.19	105.89	142.96	127.96	117.50
Head length	33.41	31.83	36.04	38.52	34.95
Head width	25.96	27.82	32.16	31.79	29.43
Head depth	17.14	11.31	15.89	16.96	15.33
Eye diameter	8.84	9.11	8.02	8.29	8.57
Tympanum diameter	4.13	4.06	3.77	4.52	4.12
Eye-nostril	13.69	9.87	13.04	14.17	12.69
Eye-snout	16.18	13.86	15.88	18.66	16.15
Eye-tympanum	11.12	10.11	12.25	13.2	11.67
Supalabials	12	12	14	14	–
Infralabials	9	10	11	13	–
Post-mentals	2+4	2+4	2+4	2+4	–
Ventrals	28	27	28	29	–
Internarial distance	5.1	5.09	5.26	5.19	–
Upper arm length	14.35	12.31	15.53	16.23	14.61
Lower arm length	15.62	16.03	20.76	21.56	18.49
Palm length	17.93	14.79	17.44	18.98	17.29
Femur length	18.52	18.71	25.24	24.16	21.66
Tibia length	20.75	20.72	21.08	25.55	22.03
Foot length	16.82	17.41	21.38	21.1	19.18
T4 lamellae	20	18	20	20	–
Sex	M	M	F	F	–

Table 4B. Data for *Gekko nicobarensis.*

Species	*Gekko nicobarensis*	*Gekko nicobarensis*	*Gekko nicobarensis*	Mean
Catalogue Number:	DOSMB05102	ZSI/ANRC/T/5234	ZSI/ANRC/T/4235	
Island	Car Nicobar	Teressa	Camorta	
SVL (mm)	91.21	95.86	78.42	88.50
Trunk length	33.74	45.34	44.65	41.24
Tail	61	63.18	61.57	61.92
Head length	25.14	27.26	22.65	25.02
Head width	17.45	20.38	18.33	18.72
Head depth	10.07	12.7	11.02	11.26
Eye diameter	5.55	7.13	5.76	6.15
Tympanum diameter	1.75	3.14	2.4	2.43
Eye-nostril	8.21	9.13	8.91	8.75
Eye-snout	10.54	11.94	11.54	11.34
Eye-tympanum	7.74	8.87	6.71	7.77
Supalabials	10	13	12	–
Infralabials	10	11	10	–
Post-mentals	2+6	2+6	2+6	–

Table 4B (continued). Data for *Gekko nicobarensis*.

Species	*Gekko nicobarensis*	*Gekko nicobarensis*	*Gekko nicobarensis*	Mean
Ventrals	29	32	29	–
Internarial distance	4	4.46	3.45	–
Upper arm length	11.1	8.15	9.97	9.74
Lower arm length	10.54	10.36	11.16	10.69
Palm length	10.11	9.77	8.27	9.38
Femur length	15.74	15.8	15.1	15.55
Tibia length	14.58	15.55	13.14	14.42
Foot length	12.97	12.92	11.88	12.59
T4 lamellae	17	14	19	–
Sex	F	F	F	–

Table 4C. Data for *Gekko stoliczkai* **sp. nov.**

Species	*Gekko stoliczkai* **sp. nov.**	*Gekko stoliczkai* **sp. nov.**	*Gekko stoliczkai* **sp. nov.**	*Gekko stoliczkai* **sp. nov.**	*Gekko stoliczkai* **sp. nov.**	Mean
Catalogue Number:	**ZSI/ANRC/T/6092**	DOSMB05020	ZSI/ANRC/T/6093	ZSI/ANRC/T/4796	ZSI/ANRC/T/7221	
Island	Little Nicobar	Great Nicobar	Great Nicobar	Great Nicobar	Great Nicobar	
SVL (mm)	118.37	122	123.83	128.4	116.29	121.78
Trunk length	55.33	51.85	55.2	60.64	49.08	54.42
Tail	105.9	112	130.49	81.31	103.81	106.70
Head length	32.1	31.6	30.22	36.93	30.43	32.26
Head width	24.04	23.43	21.46	25.07	23.19	23.44
Head depth	14.17	14.28	12.93	14.54	13.69	13.92
Eye diameter	7.84	6.76	8.05	8.66	7.68	7.80
Tympanum diameter	4.3	3.12	3.29	3.93	2.63	3.45
Eye-nostril	11.77	11.16	12.15	13.94	11.54	12.11
Eye-snout	15.04	14.05	14.95	17.15	14.51	15.14
Eye-tympanum	10.76	9.76	10.22	11.16	9.96	10.37
Supalabials	14	14	14	17	15	–
Infralabials	13	12	12	13	12	–
Post-mentals	2+4	2+4	2+4	2+4	2+4	–
Ventrals	22	25	23	21	22	–
Internarial distance	3.61	3	4.47	4.75	4.39	–
Upper arm length	11.28	16.99	12.46	13.12	12.28	13.23
Lower arm length	13.84	15.9	17.68	16.02	15.71	15.83
Palm length	15.54	16.83	12.84	16.15	11.29	14.53
Femur length	19.91	20.96	18.88	20.96	21.15	20.37
Tibia length	18.19	20.06	17.78	18.32	16.51	18.17
Foot length	16.08	19.85	15.53	17.28	15.91	16.93
T4 lamellae	21	22	18	20	21	–
Sex	M	F	F	M	M	–

Diagnosis. A large-bodied gecko (SVL 116–128.83 mm) restricted to the southern islands of the Nicobar archipelago, characterized by: 14–17 supralabials; 12 or 13 infralabials; two elongate inner pair of postmentals in broad medial contact with each other; two smaller, separated outer pairs of postmentals; 13–15 precloacal pores in males, no femoral pores; two internasals in contact with each other; distinct ventrolateral dermal folds; 21–25 transverse rows of ventrals; 10–12 transverse rows of enlarged, rounded dorsal tubercles; three enlarged post-cloacal spurs on each side of the vent; 18–22 undivided subdigital lamellae under toe IV; presence of five legible, light-colored, creamy white, transverse bands in juveniles, subadults and adults have a pale-white to creamy yellow venter.

Fig. 9. Lateral, ventral, and dorsal profiles of the head, and precloacal region of the holotype of *Gekko stoliczkai* **sp. nov.**

Description of the holotype (ZSI/ANRC/T/6092). An adult male, measuring 118.37 mm SVL, head fairly large (HL:SVL 0.27), longer than broad (HL:HW 1.34); with a blunt, rounded snout tip. Eyes fairly large (ED:HL 0.24) with a vertically elliptical pupil; eye slightly smaller than the snout length (ED:ES 0.52); nostrils situated closer to the snout tip than to the eyes (EN:ES 0.78). Trunk slightly shorter than one-half the length of the body (AG:SVL 0.47). Overall habitus depressed. Supralabials 14 on each side, infralabials 13 on each side; two moderately enlarged postmentals in broad medial contact, followed by two pairs of enlarged scales, that are nearly as large as the post-mentals. Dorsum bearing 11 transverse rows of enlarged, rounded tubercles. Ventrals imbricate, in 22 transverse rows. Two pairs of enlarged, rounded cloacal spurs present at the base of the vent on each side. Subcaudals horizontally elongate, the mid-anterior scales not enlarged. Tail slightly shorter than the body (SVL:TAL 1.12). Upper arm shorter than lower arm (UAL:LAL 0.82); palm with enlarged, undivided subdigital lamellae; the first one with an indistinct claw; relative lengths of fingers IV>III>V>II>I. Thighs short (FEL:SVL 0.17) and robust; with a few tubercles on the dorsal surface. Tibia shorter than thighs (TBL:SVL 0.15); toes with entire, undivided subdigital lamellae, 21 on toe IV; relative lengths of toes IV>III>V>II>I. Fifteen undivided series of precloacal pores; the pore-bearing scales relatively smaller than those above. Fingers and toes free, lacking membranous skin flaps.

Coloration. In life, overall ground coloration dull-brown with five or six indistinct pale-white transverse cross-bars on the body. Tail regenerated and uniform brown. Venter brown with small brown spots on each ventral scale. Eyes with vertically elliptical pupils and a bluish iris. In preservation, the dorsal coloration faded to a near-uniform dull brown with a pale white venter. The transverse bars barely visible and the bluish coloration of the iris faded.

Variation. Measurements and scale counts of the paratypes are given in Table 4. Females lack precloacal pores and are nearly as large as males. Light-colored, creamy white, transverse bands are more legible in juveniles and subadults while the adults usually have feeble dorsal bands. Ventral color ranges from pale-white to creamy yellow.

Natural history. Nocturnal and found in a variety of habitats ranging from evergreen forests, semi-evergreen forests, and plantations to human habitations. Frequently observed on walls of buildings, or on tree trunks of tall trees at heights ranging from about 6 to 13 feet. Calls comprise a series of repeatedly uttered, interrupted rattling syllables of *tuk...tuk...tuk...tuk* advancing into high frequency syllables of *tuk-tuk-tuk-tuk* (also see Biswas 1984).

Comparisons. *Gekko stolickzkai* **sp. nov.** can be

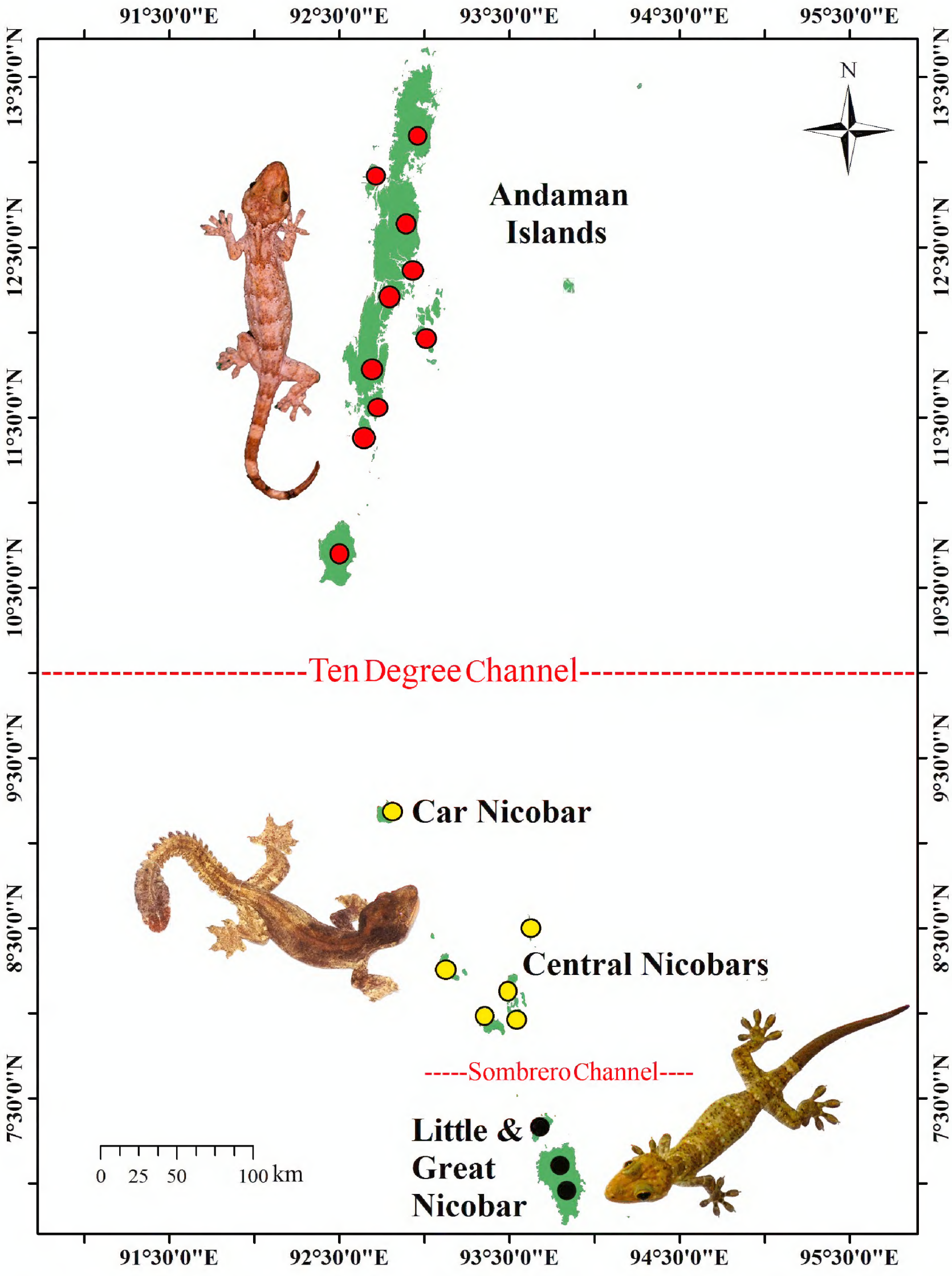

Fig. 10. Map of the Andaman and Nicobar Islands showing the distributions of *Gekko verreauxi* (red), *Gekko nicobarensis* (yellow), and *Gekko stoliczkai* **sp. nov.** (black).

differentiated from *G. smithii* by having significantly fewer numbers of internasals and ventrals and having significantly higher numbers of infralabials and supralabials (Tables 1–3; Figs. 1–2). It can be further separated from *G. smithii* by its less gracile more stout body features, in having a significantly narrower and shorter head and snout, a significantly smaller orbit, and significantly shorter limbs and trunk. From *G. verreauxi,* it is differentiated by the separation of nasal and rostral scales (vs. in contact in *G. verreauxi*), bluish iris (vs. greenish in *G. verreauxi*), and greater number of supralabials (14–17 in *G. stoliczkai* **sp. nov.** vs. 12–14 in *G. verreauxi*). From *Gekko nicobarensis*, *G. stoliczkai* **sp. nov.** can easily be distinguished by the absence of skin-

flaps along the sides of the body and tail, and extensive webbing between fingers and toes (vs. present in *G. nicobarensis*), and by the separation of nasal and rostral scales (vs. in contact in *G. nicobarensis*). Additionally, from other members of the *Gekko gecko* group, the new species *G. stoliczkai* **sp. nov.** could be distinguished as follows (only opposing suite of characters mentioned): *G. albofasciatus* (16 precloacal pores and reddish olive dorsal coloration), *G. gecko* (11–15 supralabials; gray to bluish or brownish dorsal color with reddish spots), *G. nutaphandi* (12–14 supralabials; 17–22 precloacal pores in males; 15 subdigital lamellae under toe IV), *G. reevesii* (10–14 supralabials; 13–20 precloacal pores; gray-green to dark grey dorsal coloration), and *G. siamensis* (13–21 supralabials; 10–13 precloacal pores; grey-brown to dark green dorsal coloration) *fide* Rösler et al. (2011).

Distribution. Recorded during the present study from Great and Little Nicobar Islands. It has been reported from other smaller islands such as Pigeon, Pilo Milo, Menchal, and Kondul in the southern group of the Nicobar Islands (Vijayakumar 2005) (Fig. 10).

Discussion

A fairly recent taxonomic review of the genus *Gekko* by Rösler et al. (2011) defined six species groups based on morphological and phylogenetic evidence and classified the members that formed six sub-clades. As per their scheme of classification, *Gekko smithii* and *G. verreauxi* fall under the *Gekko gekko* group, among which, *G. smithii* was shown to comprise a complex of several populations within the Sundaland. The subsequent classification of this group under the subgenus *Gekko* by Wood et al. (2019) is in agreement with that of Rösler et al. (2011). Although Das (1999) doubted that the Nicobar population of *G. smithii* was potentially allied to an undescribed member of this group from Sumatra and specifically distinct from the nominate species, *Gekko smithii*, no taxonomic assessments of this population have been made until now, despite several of the earlier field-based observations, collections, and records (Biswas and Sanyal 1977; Vijayakumar 2005; Harikrishan et al. 2014). The present study has filled in this long-standing lacuna by providing taxonomic clarity for the Nicobarese population. A report of the 'presence' of *Gekko smithii* from Camorta in the central Nicobar Islands by Harikrishnan et al. (2014: 18) is erroneous and it does not occur there (pers. obs.).

Additionally, this study provides new data on the other poorly-known members of the genus *Gekko* found in the Andaman and Nicobar Islands, especially *G. verreauxi*, which is restricted to the Andaman archipelago. Although earlier studies provided some information on taxonomy and field observations (Ota et al. 1991; Veselý 1999), this species has remained poorly known until now. Mohan et al. (2020) studied intraspecific genetic variation within *G. verreauxi* across the Andaman Islands and found it to be low, implying a genetic uniformity across the island populations, as expected (e.g., as in *Phelsuma andamanensis* and *Cyrtodactylus rubidus*). The other species, *Gekko* (*Ptychozoon*) *nicobarensis* was variously attributed to *Ptychozoon homalocephalum* and *Ptychozoon kuhli* historically (Stindachner 1867), until Das and Vijayakumar (2009) identified this population to be specifically distinct, thereby conferring it the name *Ptychozoon nicobarensis*. They diagnosed the species based on 'dorsum with tan vertebral stripe, lacking dark transverse bars' (Das and Vijayakumar 2009: 10). Their description was based on a commendable series of 20 specimens, comprising seven males and 13 females. However, our new material for this species indicates that it is much more variable in morphology and color pattern than previously ascertained, and can have either a striped or banded dorsal pattern (Fig. 3). The Andaman Islands are separated from the Nicobar Islands by the Ten-Degree Channel, which acts as an effective biogeographic barrier, limiting the distribution of *G. verreauxi*. Likewise, the Sombrero Channel running between the central and southern groups of Nicobar Islands act as a barrier in limiting the distributions of *G. nicobarensis* and *G. stoliczkai* **sp. nov.** The Great Channel, running between Great Nicobar and Sumatra, acts as a biogeographic barrier which separates the distribution ranges of *G. stoliczkai* **sp. nov.** (Southern Nicobar Islands) and the Sundaic Island of Sumatra, occupied by *Gekko smithii*. Among these, the conservation status has been assessed only for '*G. smithii*' as Least Concern. Considering the relatively wide geographic distribution and fairly high abundance (pers. obs.), we recommend *G. verreauxi* to be classified under the Least Concern category, while the other two species, *G.* (*P.*) *nicobarensis* and *Gekko stoliczkai* **sp. nov.,** with their distribution ranges restricted to a few relatively smaller islands, would fall under the Endangered category, owing to their much narrower geographic distributions.

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L. Lee Grismer studies phylogeny, taxonomy, biogeography, and character evolution in amphibians and reptiles from Southeast Asia. Lee has been working throughout the region for over 25 years, and he has contributed significantly towards studies on the systematics of the Oriental gekkonid genus *Cyrtodactylus*.

Appendix 1. Comparative material of *Gekko smithii* examined.

Peninsular Malaysia: LSUHC 3891, LSUHC 3990, LSUHC 4681, LSUHC 4694, LSUHC 4697, LSUHC 5059, LSUHC 5060, LSUHC 5061, LSUHC 5062, LSUHC 5063, LSUHC 5151, LSUHC 5152, LSUHC 5390, LSUHC 5399, LSUHC 5849, LSUHC 6260, LSUHC 6265, LSUHC 6277, LSUHC 6278, LSUHC 6282, LSUHC 6283, LSUHC 6284, LSUHC 6542, LSUHC 6564, LSUHC 6606, LSUHC 6890, LSUHC 7024, LSUHC 7025, LSUHC 7026, LSUHC 7251, LSUHC 7257, LSUHC 7263, LSUHC 7264, LSUHC 7299, LSUHC 7648, LSUHC 7649, LSUHC 7650, LSUHC 7651, LSUHC 7694, LSUHC 7702, LSUHC 9153, LSUHC 9154, LSUHC 9155, LSUHC 9156, LSUHC 9157, LSUHC 9158, LSUHC 9626, LSUHC 9959, LSUHC 10585, LSUHC 10596, LSUHC 11976, LSUHC 11977, LSUHC 12028, LSUHC 13476, LSUHC 13624, LSUHC 13625, LSUHC 13626, LSUHC 13627, LSUHC 15041, LSUHC 15042, LSUHC 15052, LSUHC 15053, LSUHC 185107, LSUHC 185112, LSUHC 185113, LSUHC 185119, LSUHC 185126, LSUHC 185135, LSUHC 185136, LSUHC 185139, LSUHC 185141, LSUHC 185142, LSUHC 185144. FMNH 185145, FMNH 185114, FMNH 185120.

Thailand: THMNH 1841, THMNH 1844, THMNH 3247, THMNH 11432, THMNH 13910.

Sumatra: FMNH 209498–503, USNM 29396, USNM 197804; MVZ 21122–25; ZMA 17947A–B, 17952.

Borneo: FMNH 128893–95, FMNH 129492, FMNH 129495–96, FMNH 131520–22, FMNH 230176, 246237–28, 248986; ZRC 2.5302, ZRC 2.5691, ZRC 2.5704, 2.1488.